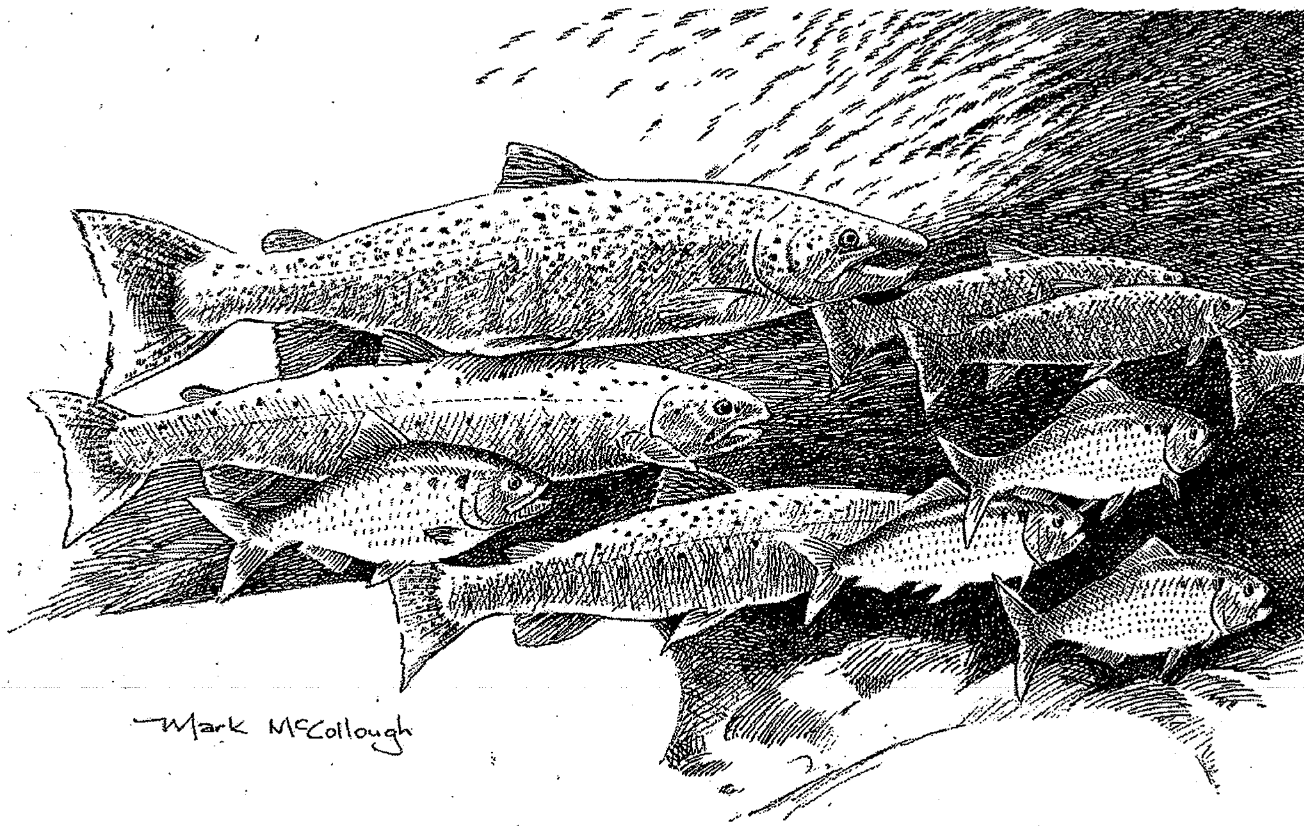
ATTACHMENT C

Status Review for Anadromous Atlantic Salmon (*Salmo salar*) in the United States



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July 2006

Acknowledgements

Clem Fay was a key member of the Atlantic Salmon Biological Review Team (BRT) until he passed away in October of 2005. His understanding of ecological processes was unrivaled, and his contributions to this document were tremendous. Since his passing preceded the publication of this Status Review, he was not able to see the completion of this project.

We would also like to acknowledge Jerry Marancik's early contributions to this project. He was a BRT member until he retired in the spring of 2004. At that time, Scott Craig assumed Jerry Marancik's role on the BRT.

We would also like to acknowledge the many people who contributed to the completion of this document. Primarily, the work of previous Atlantic Salmon BRTs helped form the basis of this document. Previous BRT members include M. Colligan, J. Kocik, D. Kimball, J. Marancik, J. McKeon, P. Nickerson, and D. Beach. Many other individuals contributed helpful comments, ideas, and work products including D. Belden, E. Cushing, R. Dill, N. Dube, M. Hachey, C. Holbrook, D. Kusnierz, P. Kusnierz, C. Legault, G. Mackey, S. MacLean, L. Miller, M. Minton, K. Mueller, J. Murphy, S. Rumsey, G. Russell, A. Spidle, and J. Wright.

The Center for Independent Experts facilitated a very helpful peer review of the January 2006 version of this document. Independent reviews by P. Bentzen, I.A Fleming, T.L. Marshall, and T. Potter were thoughtful and thorough. This version of the document reflects changes made by the BRT as a direct result of that peer review.

Finally, we would like to thank Mark McCollough for providing the cover art for this document.

Literature Citation Should Read as Follows:
Fay, C., M. Bartron, S. Craig, A. Hecht, J. Pruden, R. Saunders, T. Sheehan, and J. Trial. 2006. Status Review for Anadromous Atlantic Salmon (*Salmo salar*) in the United States. Report to the National Marine Fisheries Service and U.S. Fish and Wildlife Service. 294 pages.

Available at:
http://www.nmfs.noaa.gov/pr/species/statusreviews.htm

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place, including the provisions of the Conservation Plan, remained adequate to protect the species in light of current knowledge.

The BRT was reconvened to update the 1995 Status Review for Atlantic salmon and to conduct a comprehensive review of protective measures implemented in the Conservation Plan. The 1999 Status Review was made available to the public October 19, 1999 (64 FR 56297). On November 17, 1999, the Services published a proposed rule to list the GOM DPS as endangered. The GOM DPS was defined as all naturally reproducing wild populations of Atlantic salmon, having historical river-specific characteristics found north of and including tributaries of the lower Kennebec River to, but not including the mouth of the St. Croix River at the United States-Canada border and the Penobscot River above the site of the former Bangor Dam. Populations which met these criteria were found in the following rivers: Dennys, East Machias, Machias, Pleasant, Narraguagus, Sheepscot, Ducktrap, and Cove Brook.

After consideration of extensive written and oral public comments, and those of three scientific peer reviewers, the Services issued a final rule on November 17, 2000, effective December 18, 2000 (65 FR 69459). The final rule confirmed the endangered species listing as proposed, and amended it to incorporate "river-specific hatchery populations of Atlantic salmon having historical river-specific characteristics."

In the final rule listing the GOM DPS, the Services deferred the determination of inclusion of fish that inhabit the main stem and tributaries of the Penobscot River above the site of the former Bangor Dam (65 FR 69464). The deferred decision reflected the need for further analysis of scientific information, including a detailed genetic characterization of the Penobscot population. Furthermore, the Services were committed to reviewing data regarding the appropriateness of including the upper Kennebec and other rivers as part of the DPS (19 June 2003, letter from R. Bennett and P. Kurkul to Maine Governor Baldacci).

In late 2003, the Services assembled a new BRT comprised of biologists from the Maine Atlantic Salmon Commission (Joan Trial), the Penobscot Indian Nation (Clem Fay), NMFS (Tim Sheehan, Jessica Pruden, and Rory Saunders), and USFWS (Meredith Bartron, Anne Hecht, and Scott Craig). The new BRT was charged to review and evaluate all relevant scientific information necessary to evaluate the current DPS delineations and determine the conservation status of the populations that were deferred in 2000 and their relationship to the currently listed GOM DPS. This Status Review presents those findings.

Section 3: Biological Information

3.1 Life History

Atlantic salmon have a complex life history that ranges from territorial rearing in rivers to extensive feeding migrations on the high seas. As a result, Atlantic salmon go through several distinct phases in their life history that are identified by specific changes in

behavior, physiology, and habitat requirements (Figure 3.1). The following sections detail the life history typical of Atlantic salmon originating from U.S. rivers.

3.1.1 Freshwater Habitat

Watersheds with naturally reproducing Atlantic salmon populations vary widely in physical characteristics. However, for salmon to survive and reproduce, habitat must exist within a watershed for (1) spawning in late autumn; (2) feeding and sheltering during the growing period in the spring, summer, and autumn; and (3) overwintering. In addition, free migration among these habitats and the sea is necessary. Atlantic salmon habitat is best described using life stage specific combinations of depth, water velocity, substrate, and cover (Elson 1975, Egglishaw and Shackley 1985, Gibson 1993, Baum 1997; see below). Salmon streams can generally be characterized as having moderately low (0.2%) to moderately steep (1.4%) gradient. In addition to riverine habitats, lakes and ponds can also be important rearing habitat for juvenile Atlantic salmon (see Klemetsen et al. 2003 for a detailed review).

Most adult Atlantic salmon ascend the rivers of New England beginning in the spring, continuing into the fall with the peak occurring in June. Historically, the majority of the Atlantic salmon in Maine entered freshwater between May and mid July (Meister 1958, Baum 1997). Baum (1997) described variations to this pattern in run timing. In other parts of the world, differences in run timing have been shown to be heritable adaptations to local environmental conditions (Hansen and Jonsson 1991, Stewart et al. 2002). Salmon that return early in the spring spend nearly five months in the river before spawning, seeking cool water refugia (e.g., deep pools, springs, and mouths of smaller tributaries) during the summer months. Olfactory stimuli likely mediate homing to natal streams (Stasko et al. 1973).

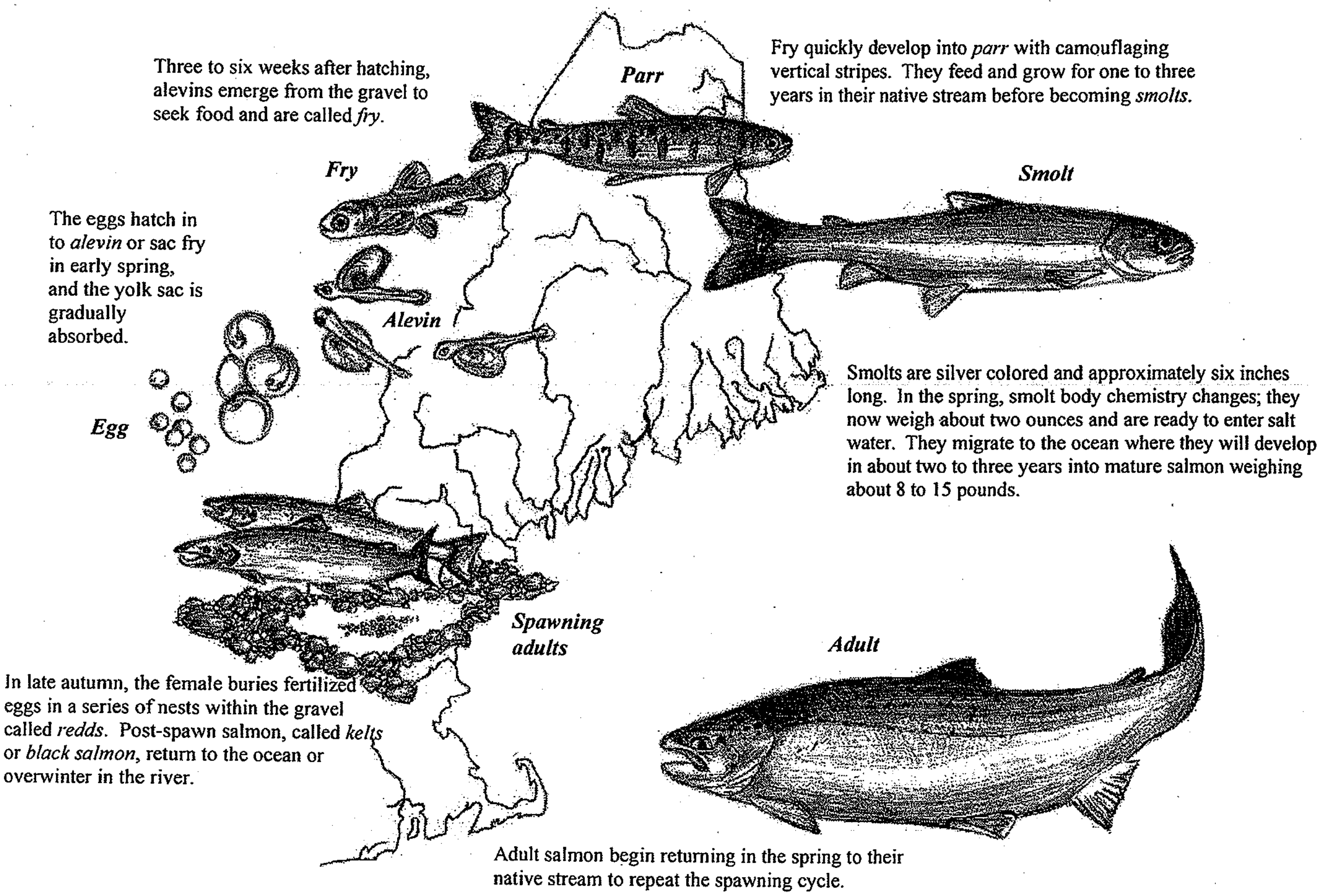

Figure 3.1. Life Cycle of the Atlantic salmon (diagrams courtesy of Katrina Mueller).

When a Maine Atlantic salmon returns to its home river after two years at sea (called a two sea winter or 2SW fish) it is on average 75 cm long and weighs approximately 4.5 kg. Some salmon, typically males, return after only one year at sea (1SW fish) at a smaller size and are termed "grilse." For the period of 1967 to 2003, approximately 10% of the wild and naturally reared origin adults returning to U.S. rivers (with monitoring facilities) were grilse and 86% were 2SW (USASAC 2004). An occasional 3SW salmon is found among returning adults. In Maine, 95 to 98% of the grilse are male while 55 to 75% of the 2SW and 3SW returns are female (Baum 1997). These ranges are a result of annual variation. Once in freshwater, adult salmon stop feeding and darken in color. Spawning occurs in late October through November.

Atlantic salmon are iteroparous (i.e., capable of spawning more than once). The degree of iteroparity is not known with certainty, but approximately 20% of Maine Atlantic salmon return to the sea immediately after spawning while the majority overwinter in the river and return to the sea the following spring (Baum 1997). Post-spawn salmon in freshwater are called kelts or black salmon. Upon returning to estuarine and marine environments, kelts resume feeding and recover their silver color. If a rejuvenated kelt survives another one to two years at sea, it will return to its home river as a "repeat spawner." From 1967 to 2003, approximately 3% of the wild and naturally reared adult returns to monitored rivers in the U.S. were repeat spawners (USASAC 2004). Thus, a spawning run of salmon may include several age groups, ensuring some level of genetic exchange between generations.

Preferred spawning habitat is a gravel substrate with adequate water circulation to keep the buried eggs well oxygenated (Peterson 1978). Water depth at spawning sites is typically 30 cm to 61 cm and water velocity averages 60 cm per second (Beland 1984). Spawning sites are often located at the downstream end of riffles where water percolates through the gravel or where upwellings of groundwater occur (Danie et al. 1984). The optimal water temperature during the spawning period ranges from 7.2°C to 10.0°C (Jordan and Beland 1981, Peterson et al. 1977). The female uses its tail to scour or dig a series of nests in the gravel where the eggs are deposited; this series of nests is called a redd. One or more males fertilize the eggs as they are deposited in the redd (Jordan and Beland 1981). The female then continues digging upstream of the last deposition site, burying the fertilized eggs with clean gravel. Total size of completed redds in Maine average 2.4 meters (m) long and 1.4 m wide (Jordan and Beland 1981). A single female may create several redds before depositing all of her eggs. In Maine rivers, eggs on average are buried under 12 to 20 cm of gravel. Female anadromous Atlantic salmon produce a total of 1,500 to 1,800 eggs per kilogram of body weight yielding an average of 7,500 eggs per 2SW female (Baum and Meister 1971). Weight loss attributable to spawning in females ranges from 12% to 47% (Baum and Meister 1971).

The eggs hatch in late March or April. At this stage, they are referred to as alevin or sac fry. Alevins remain in the redd for about six more weeks and are nourished by their yolk sac (Gustafson-Greenwood and Moring 1991). Alevins emerge from the gravel in mid-May. At this time, they begin active feeding are termed fry. The majority of fry (>95%)

emerge from redds at night (Gustafson-Marjanen and Dowse 1983). Survival from the egg to fry stage in Maine is estimated to range from 15 to 35% (Jordan and Beland 1981, MacKenzie and Moring 1988). Stream gradient, overwinter temperatures, interstitial flow, predation, disease, and competition affect survival rates (Bley and Moring 1988). Within days, the fry enter the parr stage, indicated by vertical bars (parr marks) visible on their sides; parr marks act as camouflage (Jones 1959).

Parr prefer areas with adequate cover, water depths ranging from approximately 10 cm to 60 cm, water velocities between 30 and 92 cm per second, and water temperature near 16°C (Beland 1984, Beland et al. 2004). A territorial instinct, first apparent during the fry stage, grows more pronounced during the parr stage as the parr actively defend territories (Allen 1940, Kalleberg 1958, Mills 1964, Danie et al. 1984). Water temperature (Elliot 1991), parr density (Randall 1982), photoperiod (Lundqvist 1980), competition (Hearn 1987, Fausch 1998), and food supply all influence the growth rate of parr (Swansburg et al. 2002). Maine Atlantic salmon rivers can potentially produce from 5 to 10 large parr (age 1 or older) per unit of habitat; one habitat unit equals 100 square meters of suitable habitat (Elson 1975, Baum 1997). Juvenile Atlantic salmon feed on larvae of mayflies and stoneflies, chironomids, caddisflies, blackflies, aquatic annelids, and mollusks as well as numerous terrestrial invertebrates that fall into the river (Scott and Crossman 1973, Nislow et al. 1999). In fall as flows increase and temperature and day length decrease, parr often shelter in the substrate (Rimmer et al. 1983, Rimmer et al. 1984). Movement may be quite limited in the winter (Cunjak 1988, Heggenes 1990); however, movement in the winter does occur (Hiscock et al. 2002a, Hiscock et al. 2002b) and may be necessary as ice formation reduces total habitat availability (Whalen et al. 1999).

Some male parr become sexually mature and can successfully participate in spawning with sea-run adult females. These males are referred to as "precocious parr." This alternative reproduction strategy has important implications for effective population size (Martinez et al. 2000, Jones and Hutchings 2002) and inter-generational gene flow (Fleming 1998).

In a parr's second or third spring (age 1 or age 2 respectively), when it has grown to 12.5 to 15 cm in length, a series of physiological, morphological, and behavioral changes occur (Schaffer and Elson 1975). This process, called "smoltification," prepares the parr for migration to the ocean and life in salt water. In Maine, the vast majority of wild/naturally reared parr remain in freshwater for two years (90% or more) with the balance remaining for either one or three years (USASAC 2005). During the smoltification process, parr markings fade and the body becomes streamlined and silvery with a pronounced fork in the tail. The biochemical and physiological changes that occur during smoltification prepare the fish for the dramatic change in osmoregulatory needs that come with the transition from a fresh to a salt water habitat (Ruggles 1980, Bley 1987, McCormick and Saunders 1987, USFWS 1989, McCormick et al. 1998). Naturally reared smolts in Maine range in size from 13 to 17 cm and most smolts enter the sea during May to begin their ocean migration (USASAC 2004). During this migration,

smolts must contend with changes in salinity, water temperature, pH, dissolved oxygen, pollution levels, and predator assemblages.

Survival rates for early life stages are quite variable. Overall, survival from egg to the smolt stage is estimated to range from 0.13 to 6.09% with a 90% confidence interval of 0.5 to 3.5% survival (Legault 2004). Survival for the first year of parr life is estimated to range from 12 to 58% while survival for the second year, up to smoltification, is estimated to range from 17 to 50% (Legault 2004).

3.1.2 Marine Habitat

The marine life history of Atlantic salmon of U.S. origin is not as well understood as the freshwater phase. A major obstacle to the study of Atlantic salmon in the marine environment has been the relatively low density of salmon over the extended geographic range in the ocean (Figure 3.1.2; Hislop and Shelton 1993). However, in the last 10 years there has been substantial progress in understanding the marine ecology and population dynamics of Atlantic salmon. Central to this progress has been the work of assessment committees such as the U.S. Atlantic Salmon Assessment Committee (USASAC), the International Council for the Exploration of the Sea (ICES) Working and Study Groups (the North American Salmon Study Group (ICES-NASSG) and the Working Group on North Atlantic Salmon (ICES-WGNAS).

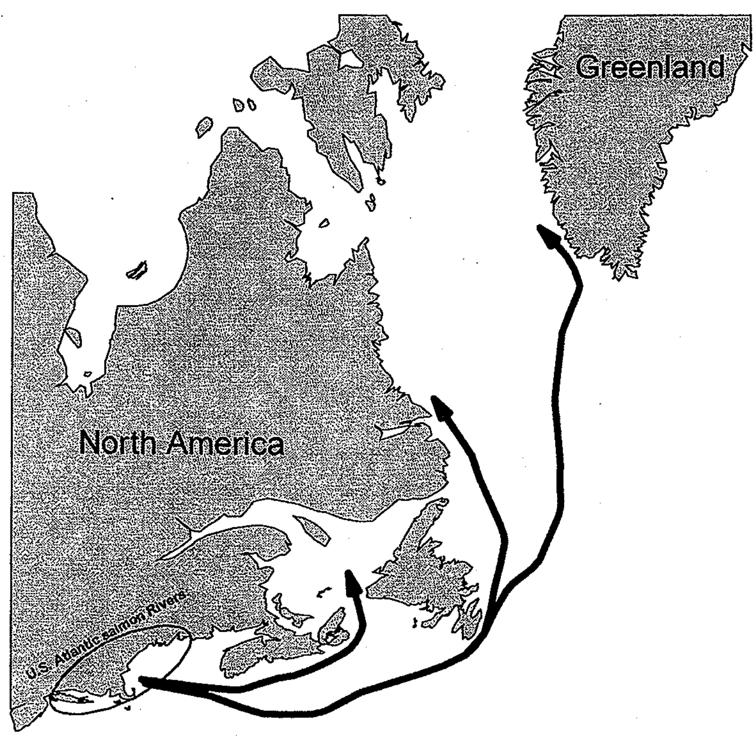

Figure 3.1.2. Generalized marine migration routes of U.S. origin Atlantic salmon.